IN THE SPECIFICATION

Please amend the specification as follows, wherein changes in a paragraph are shown by strikethrough or double brackets for deleted matter and underlining for added matter.

Page 6, delete the paragraphs beginning on line 8 with "Furthermore, the present..." and ending on page 7, line 13 with "...I/O interconnect and the socket." and replace with the following paragraphs:

--Furthermore, the present invention provides for a method for forming a device. A representative method, among others, can be summarized by the following steps: providing a first substrate having at least one optical/electrical I/O interconnect that includes a pillar transversely extending from the first substrate, wherein the pillar comprises [[of]] a first material, the first material is optically conductive, and the pillar includes a lead disposed over a portion of the pillar extending from the base of the pillar on the first substrate to the end opposite the first substrate; providing a second substrate having at least one socket adapted to receive the optical/electrical I/O interconnect, wherein the socket comprises a second material, wherein the second substrate includes a lead contact that communicatively connects the first substrate and the second substrate through the lead, wherein the second substrate includes an optical contact that communicatively connects the first substrate and the second substrate through the pillar; and causing the socket to receive a portion of the optical/electrical I/O interconnect.

Furthermore, the present invention provides for a method of aligning substrates. A representative method, among others, can be summarized by the following steps: providing a first substrate having at least one optical/electrical I/O interconnect that includes a pillar transversely extending from the first substrate, wherein the pillar comprises [[of]] a first material, the first

material is optically conductive, and the pillar includes a lead disposed over a portion of the pillar extending from the base of the pillar on the first substrate to the end opposite the first substrate; providing a second substrate having at least one socket adapted to receive the optical/electrical I/O interconnect, wherein the socket comprises a second material, wherein the second substrate includes a lead contact that communicatively connects the first substrate and the second substrate through the lead, wherein the second substrate includes an optical contact that communicatively connects the first substrate and the second substrate through the pillar; maintaining optical alignment between the first substrate and the second substrate using the optical/electrical I/O interconnect and the socket; and maintaining electrical interconnection between the first substrate and the second substrate using the optical/electrical I/O interconnect and the socket.--

Page 8, delete the paragraph beginning on line 9 with "FIGS. 3A…" and ending with "…cross-sections." and replace it with the following paragraph:

--FIGS. 3A and 3B are cross-sectional views of representative compliant sockets having a plurality of exemplary cross-sections.--

Page 9, delete the paragraph beginning on line 5 with "FIGS. 12A…" and ending with "…in FIG 11A." and replace it with the following paragraph:

--FIGS. 12A through 12F are [[a]] cross-sectional view<u>s</u> that illustrate a representative process for fabricating the pillar illustrated in FIG. 11A.--

Page 9, delete the paragraph beginning on line 20 with "FIGS. 19A…" and ending with "…in FIG. 17A." and replace it with the following paragraph:

--FIGS. 19A [[and]] <u>through</u> 19E are cross-sectional views that illustrate a representative process for fabricating the L-shaped pillar illustrated in FIG. 17A.--

Page 10, delete the paragraph beginning on line 22 with "The compliant pillar,..." and ending on page 11, line 2 with "...and 17B." and replace it with the following paragraph:

--The compliant pillar, the optical/electrical I/O interconnect, the lens/waveguide optical pillar, and the L-shaped pillar are disposed substantially transversely (*i.e.*, substantially vertical [[to the substrate]]) to the substrate as shown in the FIGS. 1A, 1B, 6, 8 11A, 11B, 17A, and 17B.—

Page 14, delete the paragraph beginning on line 19 with "Furthermore, the ..." and ending with "...index of refraction." and replace it with the following paragraph:

--Furthermore, the compliant pillar 14 can be fabricated to have varying indices of refraction within different regions. For example, if a polymer pillar is 150μm tall, the 50μm closest to the first substrate 12 can have a first index of refraction, the next 50μm can have a second index of refraction, and the last 50μm (the end opposite the first substrate 12) can have a third index of refraction.--

Page 16, delete the paragraph beginning on line 13 with "The non-flat tip..." and ending on page 17 line 2 with "...can be designed accordingly." and replace it with the following paragraph:

--The non-flat tip of the compliant pillar 14 can have various topographies such as, but not limited to, the shapes illustrated in FIGS. 1A, 1B, and 2A through 2I. For example, the non-flat tip of the compliant pillar 14 can be rounded (FIG. 2D), pointed (FIG. 2A), or squared off on a portion of the tip (FIGS. 2B and 2C). In addition, the non-flat tip can be partially slanted (FIG. 2E), have teeth cut on a portion of the tip (FIGS. 2F, 2G, and [[2H]]2I), or be concave ([[2I]]2H). The configurations illustrated in FIGS. 1A, 1B, and 2A through 2I are non-limiting and other non-flat tip configurations are included within the claimed subject matter. In general, the various

types of tip topography can facilitate two different functions. A tip topography may enhance and/or assistant in making a better mechanical interconnection between the socket and the pillar (*i.e.*, the tips in FIGS. 2B and 2C). In addition, a tip topography can be used for optical interconnection purposes (*i.e.*, the tips in FIGS. 2E through 2I). As such, the relative scale of the tip topography for each function can vary significantly and the tip topography can be designed accordingly.--

Page 21, delete the paragraphs beginning on line 11 with "Fig. 6 illustrates..." and ending on page 22, line 23 with "...if desired." and replace with the following paragraphs:

--FIG. 6 illustrates a cross-sectional view of a representative embodiment of a dual optical/electrical I/O interconnection system 40. Again, it should be noted that the figures and components are not to scale. For example, the mirrors shown may be much smaller in size than the planar waveguides shown. The dual optical/electrical I/O interconnect system 40 includes a first structure 40a and a second structure 40b. The first structure 40a includes a first substrate 12 and a dual optical/electrical I/O interconnection 41. In addition, the first substrate 12 includes, but is not limited to, a die pad 47, a first waveguide 42a, and a coupling element 46. The dual optical/electrical I/O interconnection 41 includes a pillar 44 and an electrical lead 48. The lead 48 can be deposited such that a metal or alloy fully encapsulates the pillar 44 except for an area for the optical interconnection path. Otherwise, the lead [[44]]<u>48</u> may cover only a portion of the sidewall, as shown in FIG. 6. The second structure 40b includes a second substrate 20, a socket 54, a second waveguide 42b, and an electrical contact 56. The pillar 44 has a non-flat tip (slanted tip). The electrical lead 48 is disposed on a portion of the die pad 47 and on a portion of the pillar 44 extending over the slanted area of the pillar 44. The electrical lead 48 and pillar 44 form the optical/electrical I/O interconnect 41. The socket 54 includes a solder or other adhesive

material 58 disposed therein. The socket 54 is adapted to receive the optical/electrical I/O interconnect 41. In addition, the pillar 44 and/or the socket 54 can be fabricated from compliant materials that [[are]] allow the pillar and socket to be compliant. The first substrate 12 and the second substrate 20 can include additional components, as described above. The [[lead]] electrical lead 48 can include material that is highly reflective to the optical signal wavelength.

Alternatively, without the metal lead air can be used as the waveguide cladding because no underfill is required for the pillar 44 since the pillar 44 is [[are]] laterally compliant. This enables them to compensate for the different thermo-mechanical expansions between the chip and the board. Thus, optical/electrical I/O interconnection 41 mitigates the offsets introduced due to expansion mismatches and nonplanarity. The air cladding and the resulting high index of refraction difference (Δn) between the core and the cladding has the benefit of confining the optical wave and thus minimizing crosstalk. Air cladding also has two additional benefits when compared to non-air cladding in this application: 1) the pillar 44 can guide an optical wave through larger bends (due to large Δn), which means higher compliance, and 2) the air cladding does not impose any mechanical/physical constraints on the movement of the pillar 44. Thus, air waveguide cladding offers the lowest index of refraction possible and is the least mechanically-resistant material. However, the pillar 44 may be passivated with any cladding material, if desired.--

Page 24, delete the paragraph beginning on line 5 with "The pillar 44…" and ending online 18 with "…substrate 20." and replace it with the following paragraph:

--The pillar 44 functions as a medium through which optical energy travels. As such, the pillar 44 can communicate optical energy from the first substrate 12 to the second substrate 20 using one or more waveguides that may include one or more coupling elements and/or one or

more mirrors. The waveguides, coupling elements, and/or the mirrors can be included within and/or disposed upon the first or second substrate 12 and 20. As illustrated in FIG. 6, the first substrate 12 includes the first waveguide 42a having the coupling element 46 disposed adjacent the pillar 44 (as demonstrated in R. Chen, *et al.*, "Fully Embedded Board-Level Guided-Wave Optoelectronic Interconnects," *Proc. IEEE*, Vol. 88, pp.780-793, Jun. 2000 incorporated herein by reference). The lead 48 disposed on the pillar 44 acts as a mirror on the non-flat tip (slanted portion) of the pillar 44. The second substrate 20 includes the [[first]] <u>second</u> waveguide 42<u>b</u>[[a]]. Therefore, optical energy can be directed into the pillar 44 via the first waveguide 42a and the coupling element 46 disposed on the first substrate 12, guided by the pillar 44, and directed by the mirror (lead) into the second waveguide 42b disposed on the second substrate 20.--

Page 29, delete the paragraph beginning on line 13 with "If the material..." and ending on line 19 with "...fabrication processes." and replace it with the following paragraph:

--If the material layer 50 is photosensitive, the compliant pillar can be fabricated by exposing the material [[16]] <u>50</u> in FIG. [[3B]] <u>7B</u> through a mask to a light source with an appropriate wavelength. The mask contains the cross-sectional geometry of the compliant pillars. After exposure, the exposed material layer 50 may need a hard bake before developing. During developing, a wet chemical agent can be used to remove the non-exposed portions (for negative tone films) of the material to leave behind the compliant pillars (or sockets). As a result, no hard mask is needed for the fabrication processes.--

Page 32, delete the paragraphs beginning on line 16 with "Other methods..." and ending on page 33, line 8 with "...beam evaporation." and replace it with the following paragraphs:

--Other methods for indenting or modifying the tip of the unmodified pillar 82 may include, but [[is]] are not limited to, thermally curing the unmodified pillar 82 while the mold pattern is impressed against the unmodified pillar 82 or heating and pressing the impression mold 84 on the pillar to cause local heating and local deformation. These processes can be performed after the polymer film application and softbake (FIG. 9B). Another method for indenting or modifying the unmodified pillar 82 may include, but is not limited to, spin coating the polymer, 70% soft baking, molding the film while finishing the soft bake process step, removing the mold, and then photoimaging. The slanted surfaces on the tip of the pillar 74 can also be formed by reactive ion etching (RIE). A reference describing RIE of slanted surfaces can be found in G. Boyd *et al.* "Directional Reactive Ion Etching at Oblique Angles," *Appl. Phys. Lett.*, vol. 36, no., 7, pp. 583-585, Apr. 1980,which is incorporated herein by reference.

FIG. 9G illustrates the pillar 74 after the tip has been modified. FIG. 9H illustrates a mirror layer 82 disposed upon the substrate 72 and pillar 74. The mirror layer 82 can be deposited on the substrate [[16]] <u>72</u> by methods such as, for example, sputtering, or electron beam evaporation.--

Page 33, delete the paragraph beginning on line 14 with "FIG. 9J…" and ending on line 18 with "…modified-tip structure 70." and replace it with the following paragraph:

--FIG. 9J illustrates the mirror layer 82 etched away, which forms the mirrors 76 on the tip of the pillar 74. The mirror layer 82 can also be etched using techniques such as, for example, reactive ion etching (RIE), wet etch, and laser drilling. It should be noted that the fabrication process described in FIGS. 7A through [[7G]] <u>7F</u> could be used to fabricate modified-tip structure 70.--

Page 35, delete the paragraph beginning on line 3 with "FIGS. 12A through…" and ending on line 8 with "…plasma deposition." and replace it with the following paragraph:

--FIGS. 12A through 12F are cross-sectional views that illustrate a representative process for fabricating the modified-tip structure 100a illustrated in FIG[[S]]. 11A[[and 11B]]. FIG. 12A illustrates the substrate 102, while FIG. 12B illustrates a pillar material layer 108 disposed upon the substrate 102. The pillar material layer 108 can be deposited on the substrate 102 by methods such as, for example, spin-coating, doctor-blading, and plasma deposition.--

Page 36, delete the paragraph beginning on line 3 with "Alternatively, a pillar…" and ending on line 6 with "…batch fabrication." and replace it with the following paragraph:

--Alternatively, a pillar 104 with concave/convex tip may be fabricated by locally heating the tips of the polymer pillar 104 to cause local melting. Then, removing the heat source allows the molten[[d]] polymer to cool, resolidify, and remain spherical. Such a process also allows for batch fabrication.--

Page 36, delete the paragraph beginning on line 11 with "FIG. 13 illustrates…" and ending on line 21 with "…the substrate 116." and replace it with the following paragraph:

--FIG. 13 illustrates the path that optical energy can travel using the modified-tip pillar 101a shown in FIG. 11A. Initially, the optical energy travels through the pillar 104. Upon encountering the lens 106a, the optical energy is focused onto a component 118 (*e.g.*, a detector, waveguide, or coupling element) disposed on substrate 116. FIG. 14 is only an illustrative example of how the modified-tip pillar 101a can be used. For example, the optical energy could also be focused on a component (*e.g.*, a detector, waveguide, or coupling element) disposed under the surface of the substrate 116. Further, a compliant socket can be disposed on the substrate 116, the compliant socket being analogous to the compliant socket 22 in FIG. 1A and

1B. The compliant socket can [[could]] allow z-axis alignment of the modified-tip pillar 101a and the buried component in the substrate 116.--

Page 37, delete the paragraph beginning on line 16 with "The substrate..." and ending on line 19 with "...and sockets.." and replace it with the following paragraph:

--The substrate 122 can include, but is not limited to, the components described above in reference to the first and second substrates 12 and 20. The polymer bridge material can be made of materials such as, but not limited to, the materials discussed in reference to FIGS. 1A, 1B, 2A through 2I, 3A and 3B for the pillars and sockets.[[.]]--

Page 39, delete the paragraph beginning on line 13 with "FIG. 12C..." and ending on line 15 with "...plasma deposition." and replace it with the following paragraph:

--FIG. [[12C]]<u>16C</u> illustrates the addition of a polymer bridge 124 over the sacrificial material layer 128. The polymer bridge 124a can be deposited on the substrate 122 by methods such as, for example, spin-coating, doctor-blading, and plasma deposition.--

Page 40, delete the paragraph beginning on line 1 with "FIG. 17A..." and ending on line 13 with "...lateral polymer channel." and replace it with the following paragraph:

--FIG. 17A illustrates a cross-sectional view of an L-shaped pillar 144a. The L-shaped structure 140a includes, but is not limited to, a first substrate 12a and L-shaped pillar 144a. FIG 17B illustrates a cross-sectional view <u>of</u> an alternate embodiment of a L-shaped pillar 144b with a mirror 146b fabricated at the corner of the L-shaped pillar 144b. The first substrates 12a and 12b can include additional components, as described above. The L-shaped pillars 144a and 144b can be fabricated from materials, including but not limited to, photosensitive polymers. The photosensitive polymers can include, but are not limited to, the materials discussed in reference to FIGS. 1A, 1B, 2A through 2I, 3A and 3B for the pillars and sockets. The mirror 146b can be

made of materials such as, but not limited to, metals used for simple total internal reflection. FIGS. 18A and 18B illustrate representative [[the]] top views of L-shaped pillars. Alternate embodiments (not shown) could resemble helix-like polymer interconnections or pillars terminated with a circular disk rather than a lateral polymer channel.--

Page 40, delete the paragraph beginning on line 20 with "FIGS. 19A..." and ending on page 41, line 2 with "...plasma deposition." and replace it with the following paragraph:

--FIGS. 19A [[and]] <u>through</u> 19E are cross-sectional views that illustrate a representative process for fabricating the L-shaped pillar 144a illustrated in FIG. 17A. FIG. 19A illustrates photosensitive polymer material 148 disposed upon the substrate 12a. The photosensitive polymer material 148 can be deposited on the substrate 12a by methods such as, for example, spin coating, doctor-blading, and plasma deposition.--